



INFRASTRUCTURE, SAFETY,  
AND ENVIRONMENT

***Preparing for an Uncertain Future Climate in Inland Empire:  
Identifying Robust Water Management Strategies***

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**RAND Corporation**

**with**

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**NCAR**

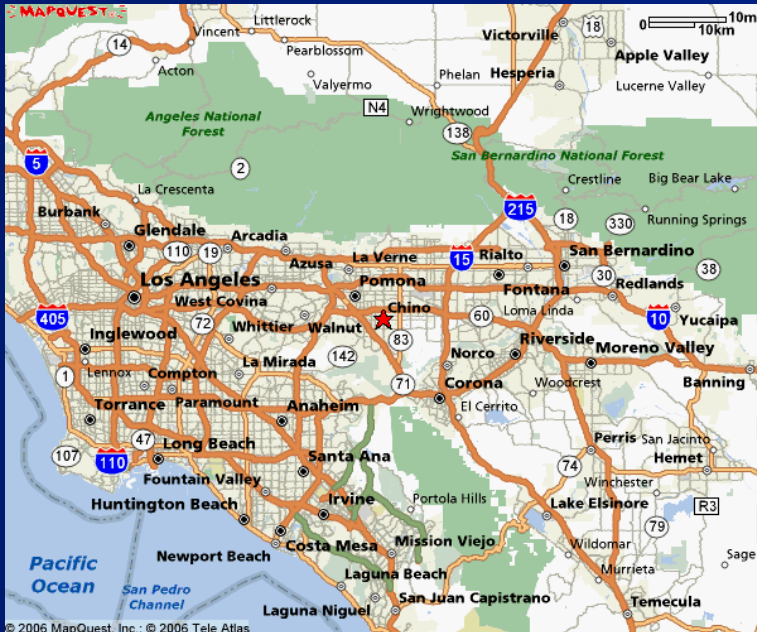
# ***Southern California's Inland Empire Utilities Agency (IEUA) Faces Significant Water Challenges***

- Rapidly growing population
  - 800,000 → 1.2 mil people by 2025
- Reliant on imports of uncertain reliability

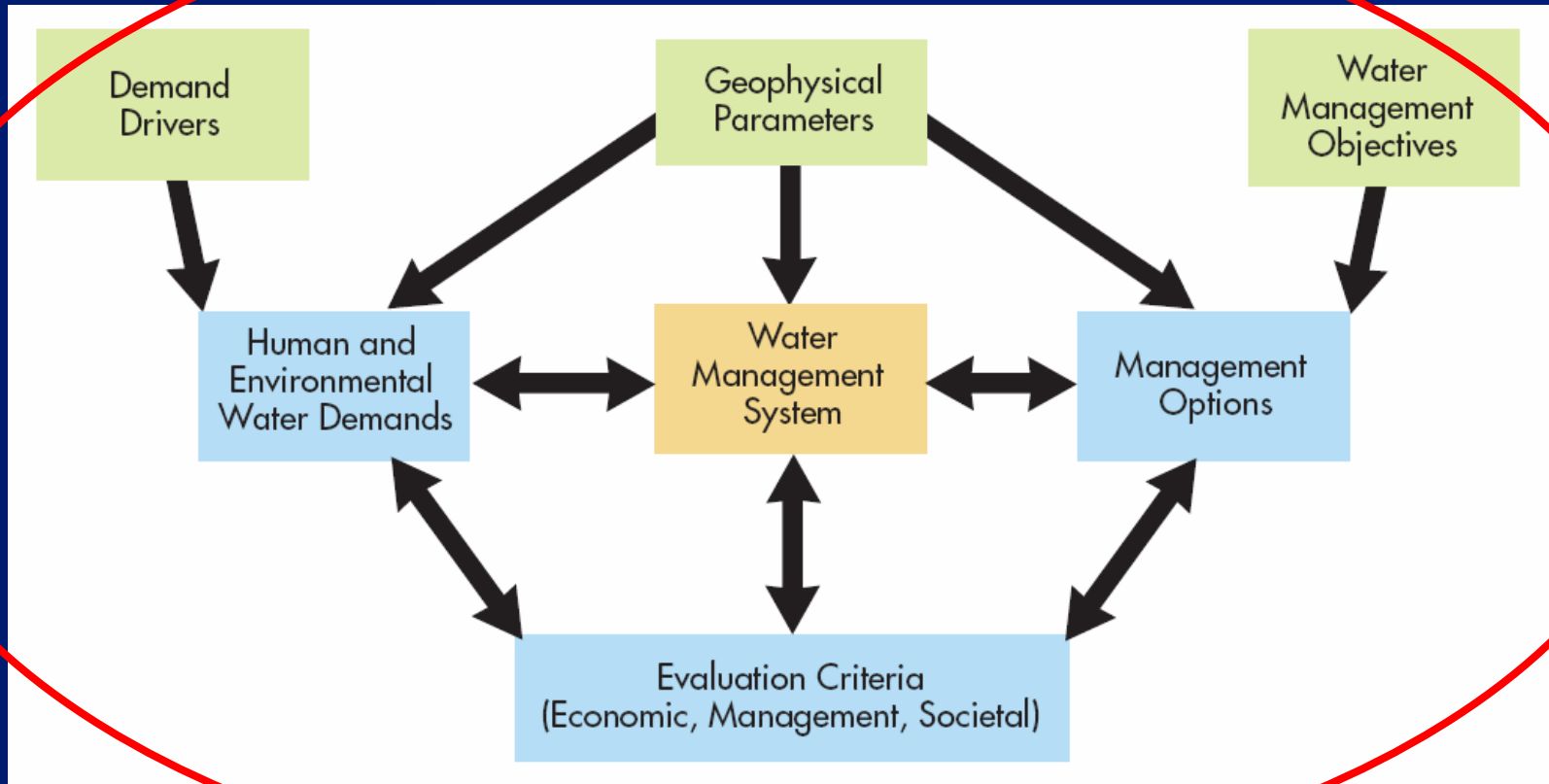


Changes in climate may:

- Increase irrigation demand
- Change precipitation patterns
- Diminish snow pack and reduce imports
- Impact groundwater recharge

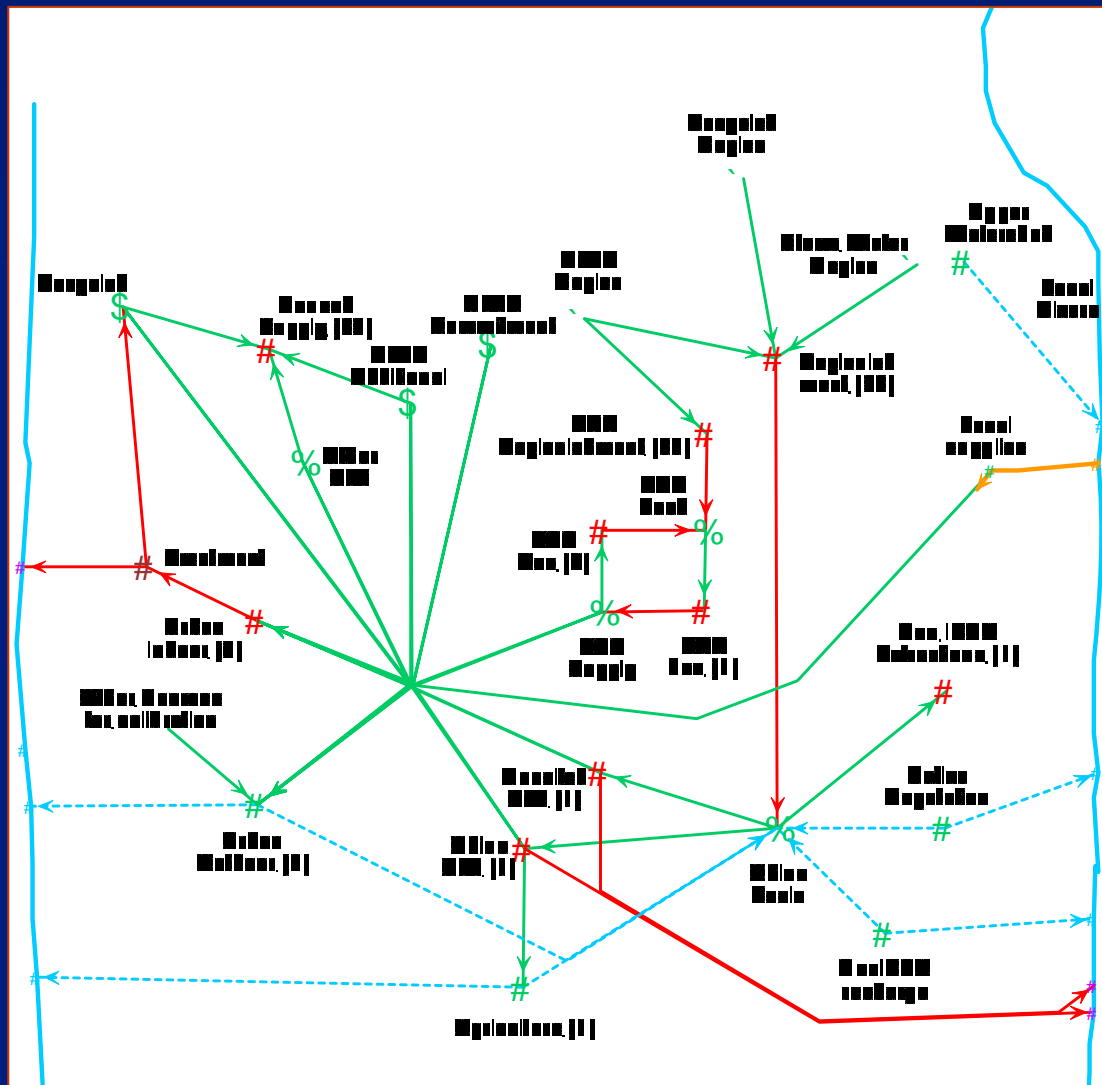


# *Study Evaluates the Performance of IEUA Water Management Strategies Against Integrated Climate/Supply/Demand Scenarios*



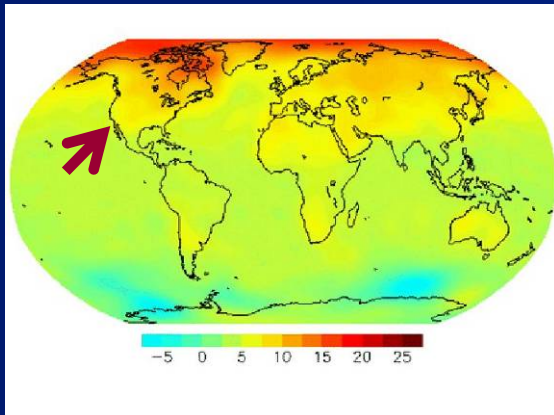
# *We Developed a WEAP Model to Assess Performance of IEUA Plans in Different Future States of World*

- Projects future water supply, demand, & reliability
  - Reflecting plausible trends of climate change
  - Consistent with IEUA management plans and assumptions
- Each run estimates:
  - Demand
  - Available supply
  - Annual shortages
  - Financial impact of shortages
  - Cost of provisioning supply

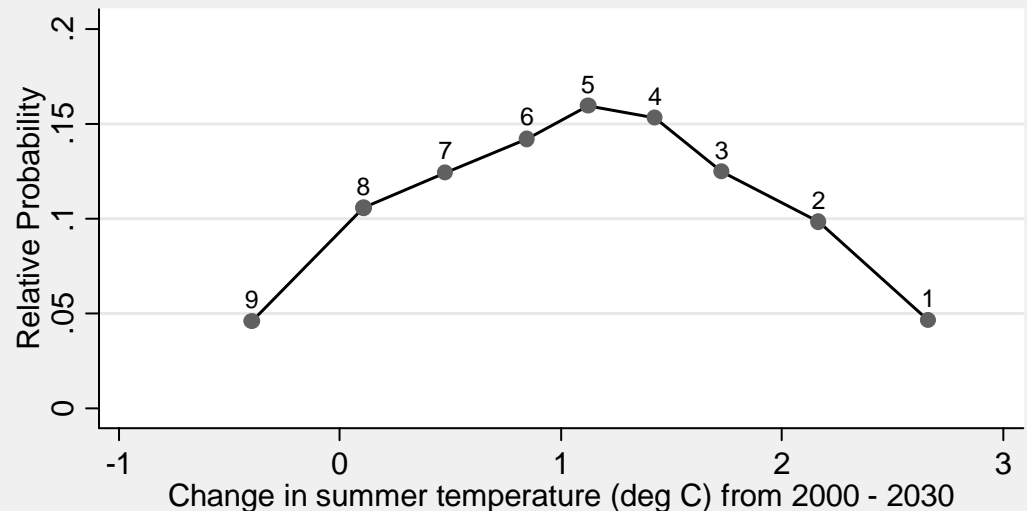
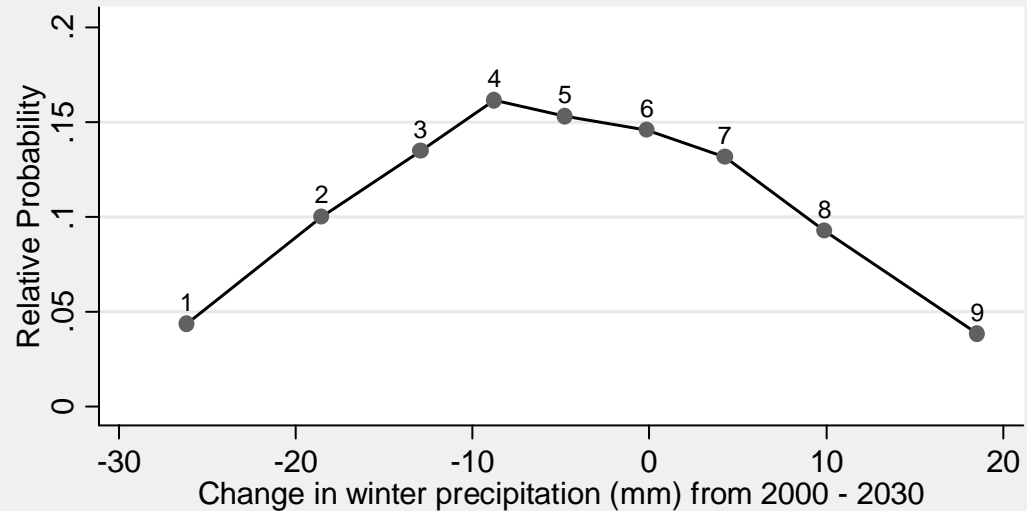


# *To Address Potential Climate Changes, We Use GCM Projections of Temperature and Precipitation for Southern California*

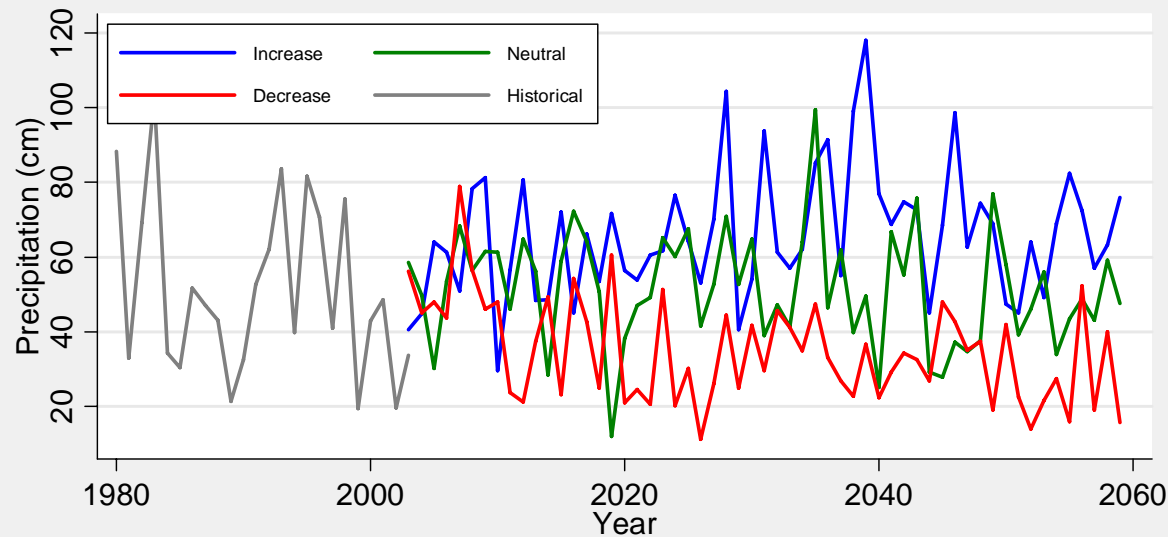
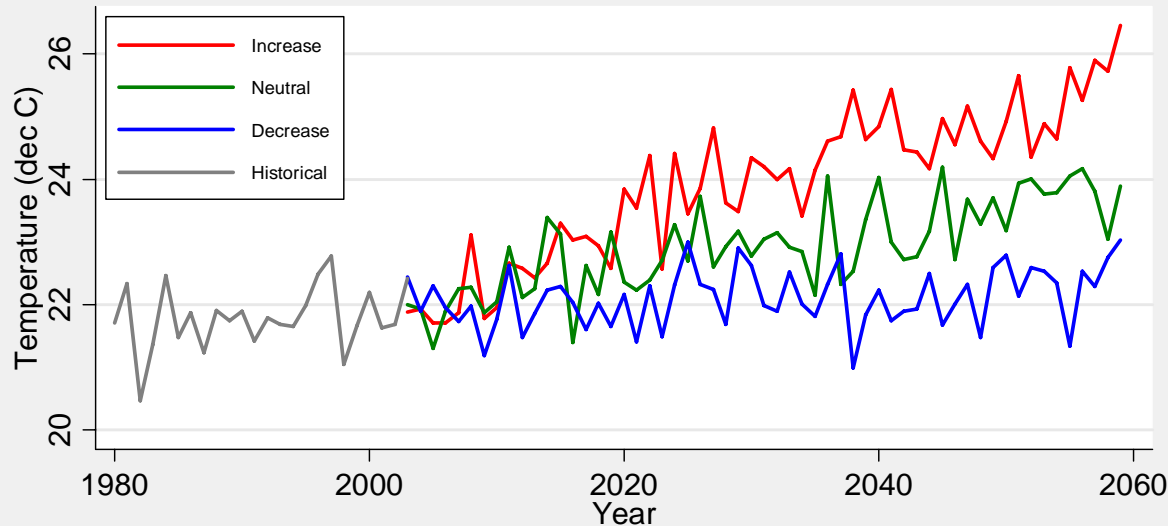
- Derived from forecasts from 9 GCMs with A1B emissions scenario
- Each forecast weighted by ability to reproduce past climate and level of agreement with other forecasts



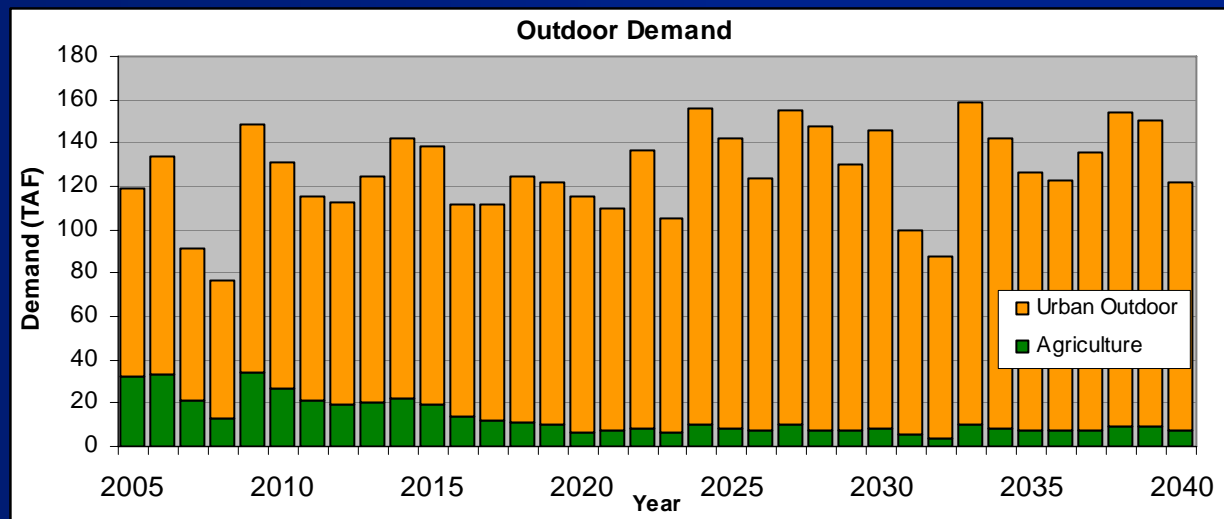
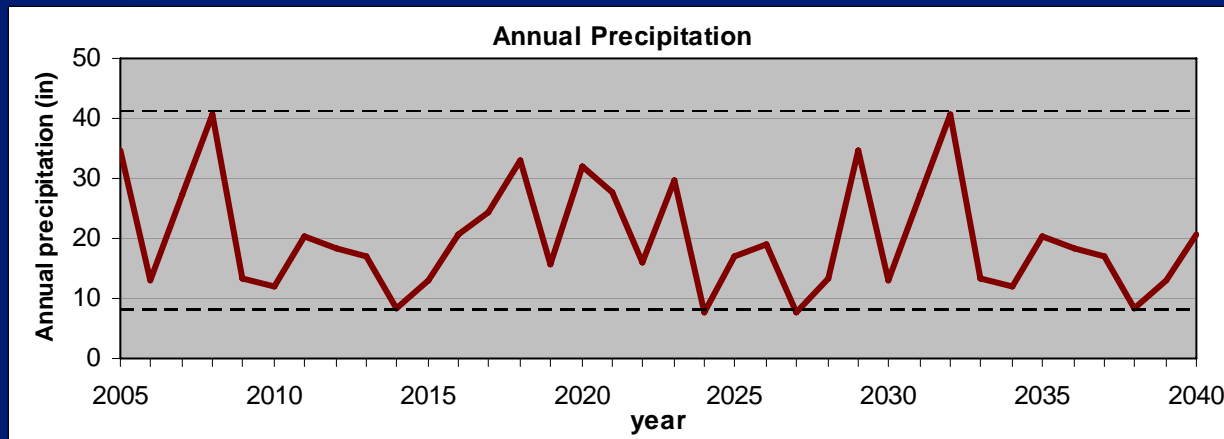
RAND (Tebaldi et al.)



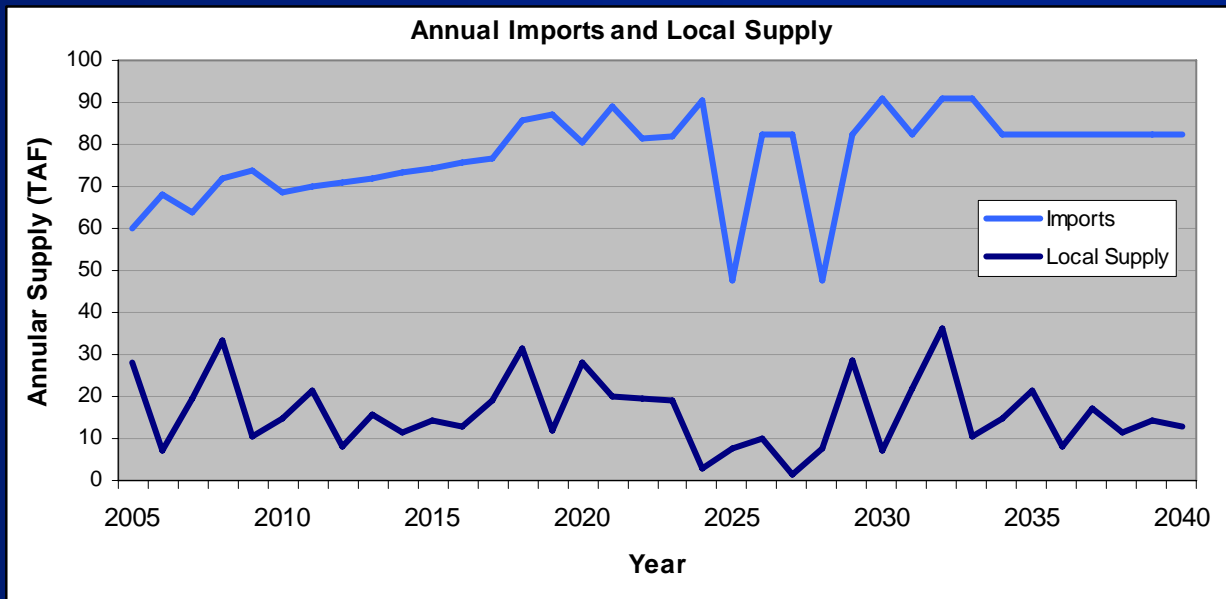
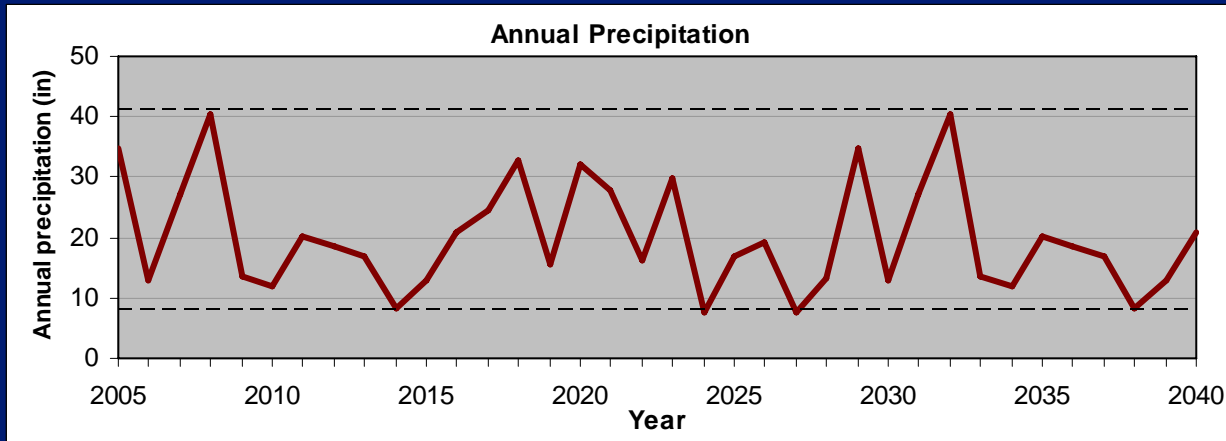
# *We Then Created Hundreds of Temperature and Precipitation Time series Reflective of Historical Weather and Plausible Ranges of Climate Change*



# *Outdoor Water Demand Varies According to Monthly Precipitation*



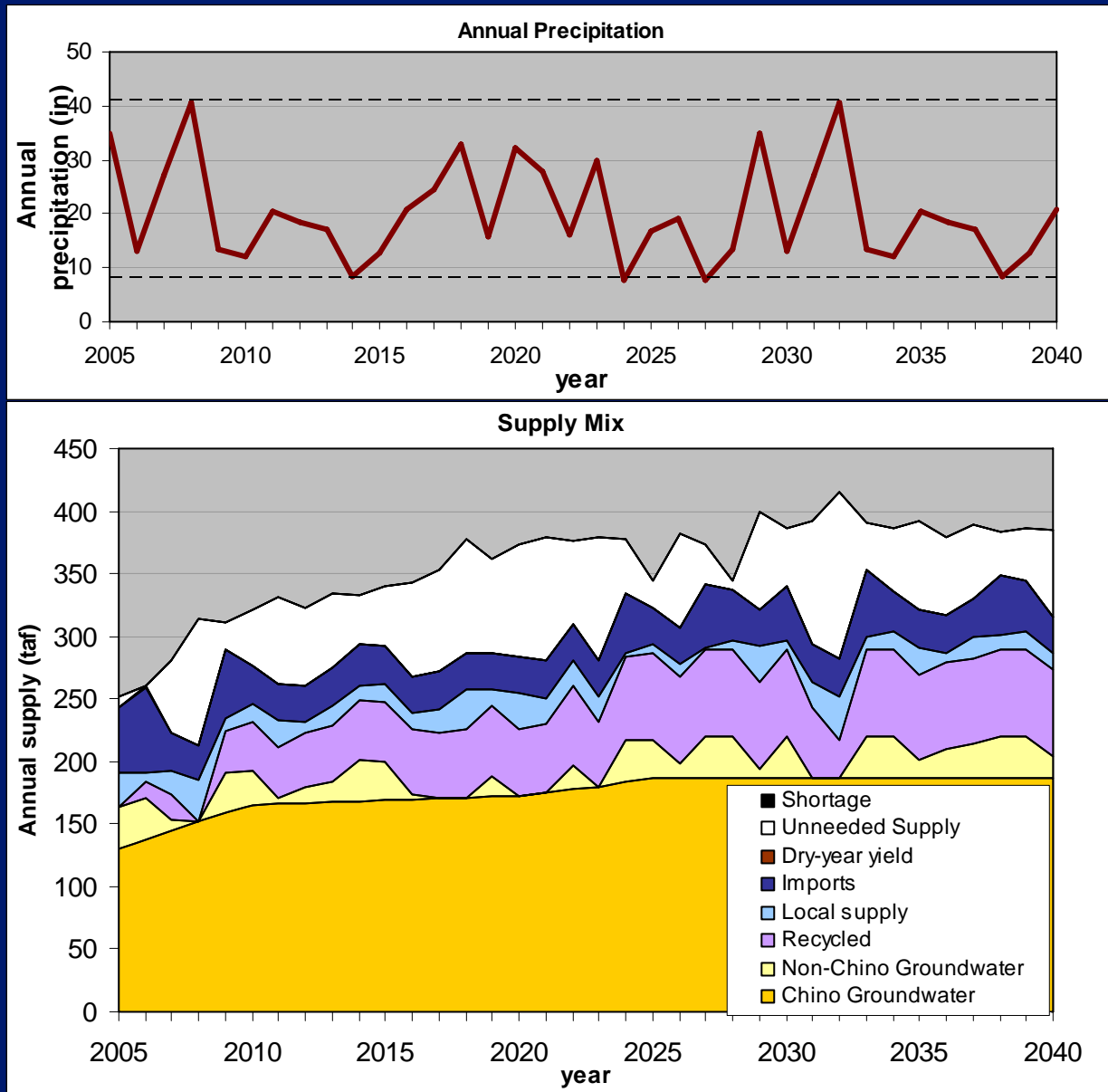
# *Imports and Local Supply Vary According to Monthly Precipitation*



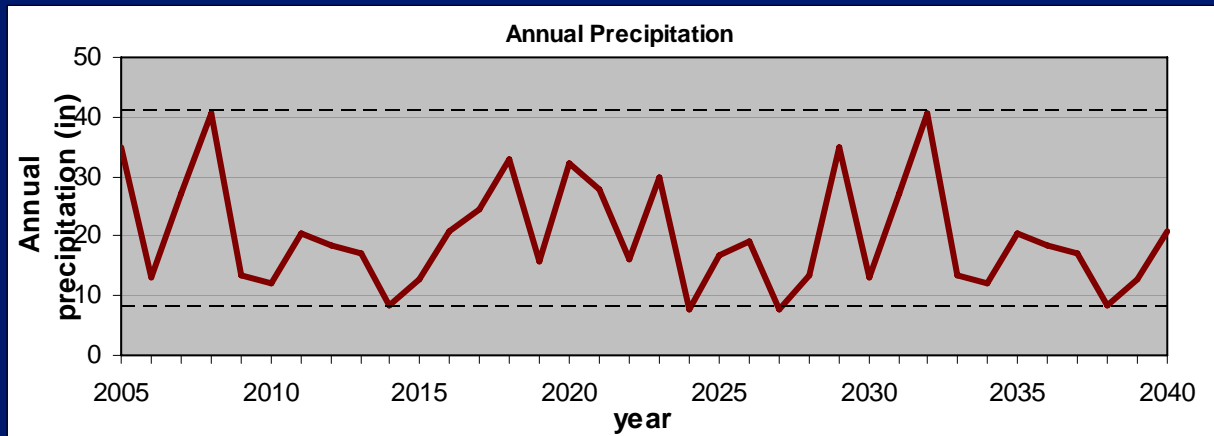


# Model Calculates Annual Supply Mix

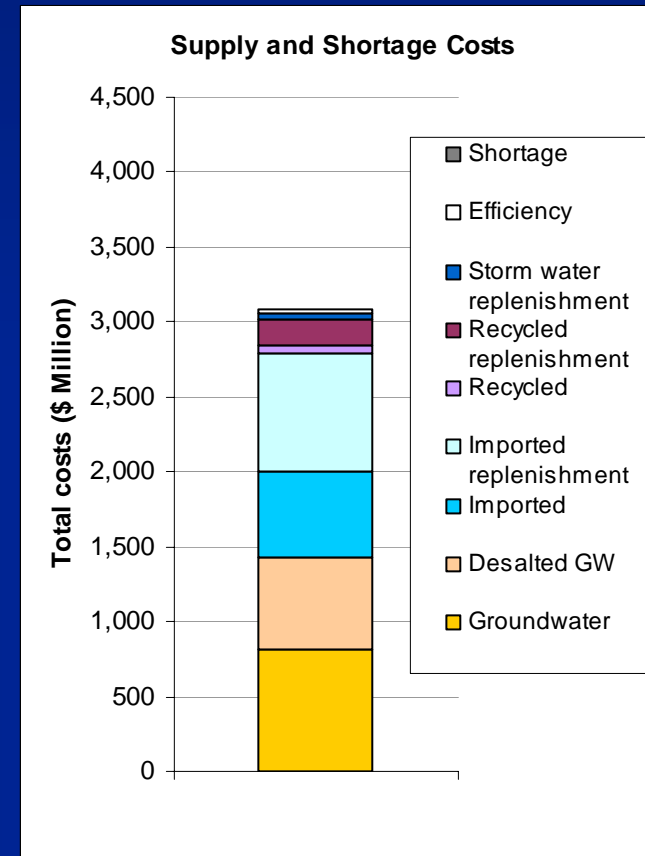
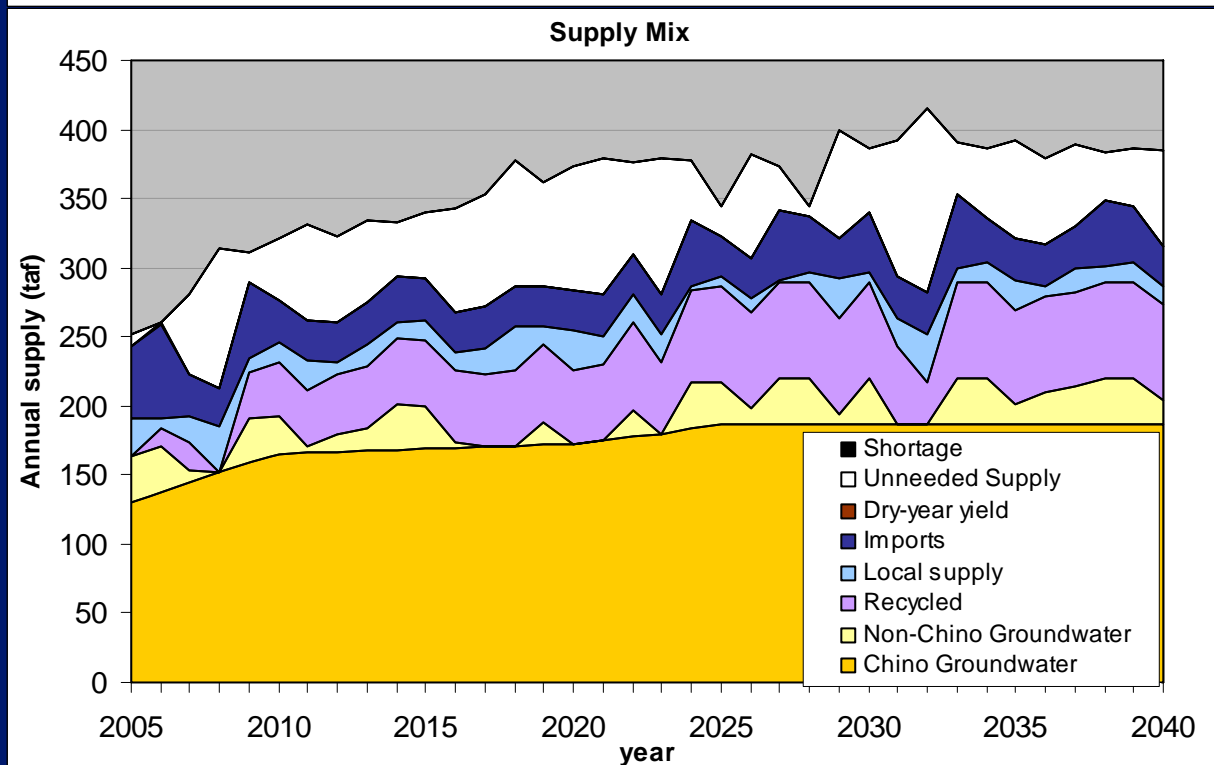
**UWMP**  
**Historical Climate**



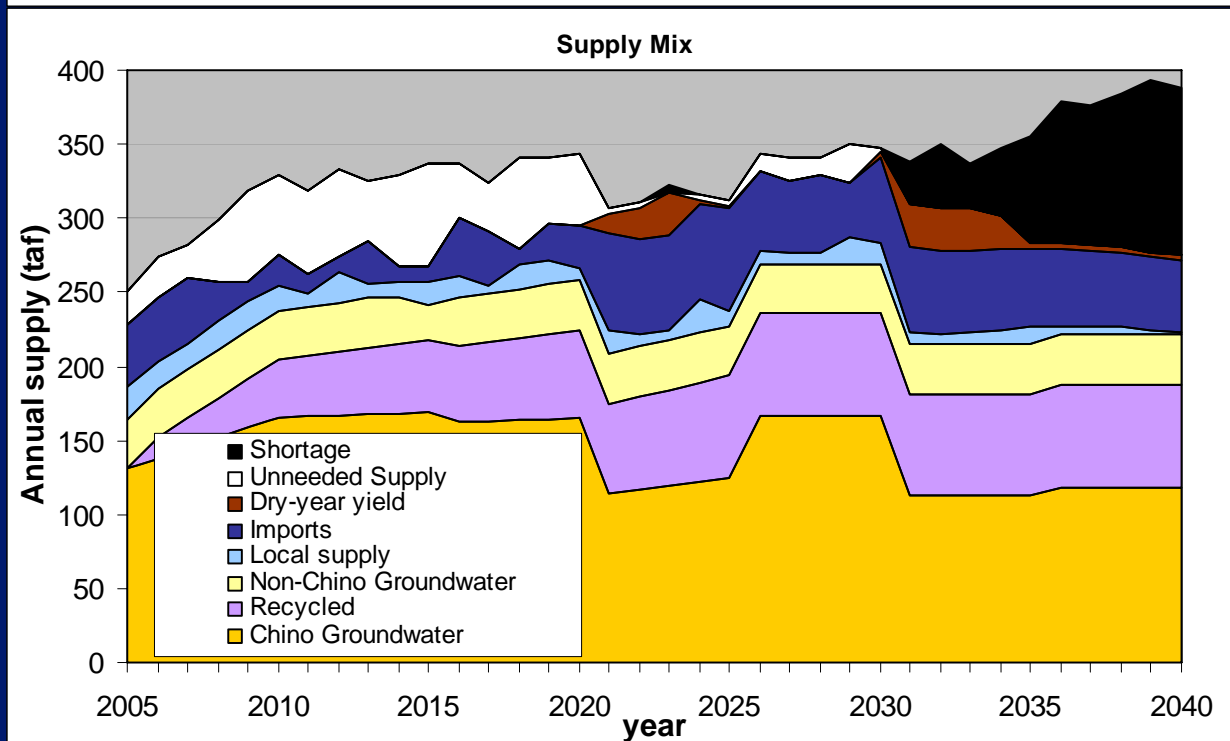
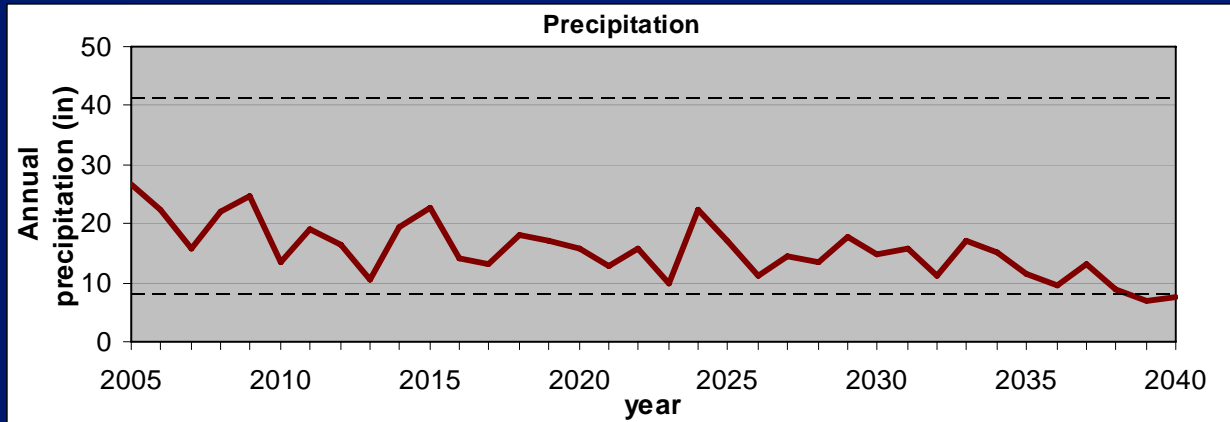
# Model Calculates Annual Supply Mix and NPV of Supply and Shortage Costs



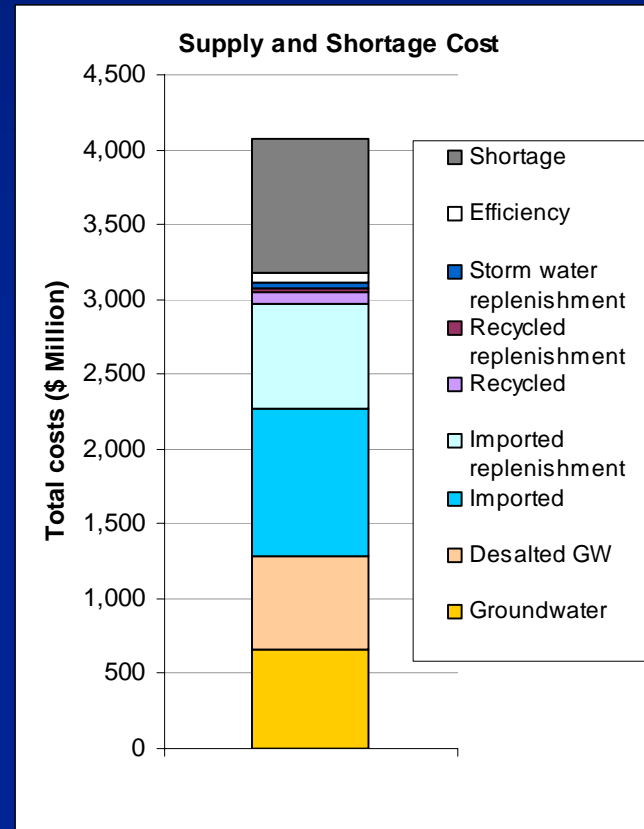
**UWMP**  
**Historical Climate**



# Model Projects Changes in Supply Mix Under Different Climate Conditions



**UWMP**  
**Adverse Conditions**



# ***We Explored Several Combinations of Adaptive IEUA Management Plans***

<b>Management Plan</b>
<b>UWMP Forever</b>
<b>UWMP + DYY and Recycling</b>
<b>UWMP + Replenishment</b>
<b>UWMP + Efficiency</b>
<b>UWMP + All Enhancements</b>
<b>UWMP w/ Updates</b>
<b>UWMP + DYY and Recycling w/ Updates</b>
<b>UWMP + Replenishment w/ Updates</b>
<b>UWMP + Efficiency w/ Updates</b>

# ***Model Evaluates How Numerous Uncertainties Would Affect the Performance of Each Plan***

## **Assumption**

**Climate change**

**Recycling delay**

**Replenishment achievement**

**Water intensity of new  
development**

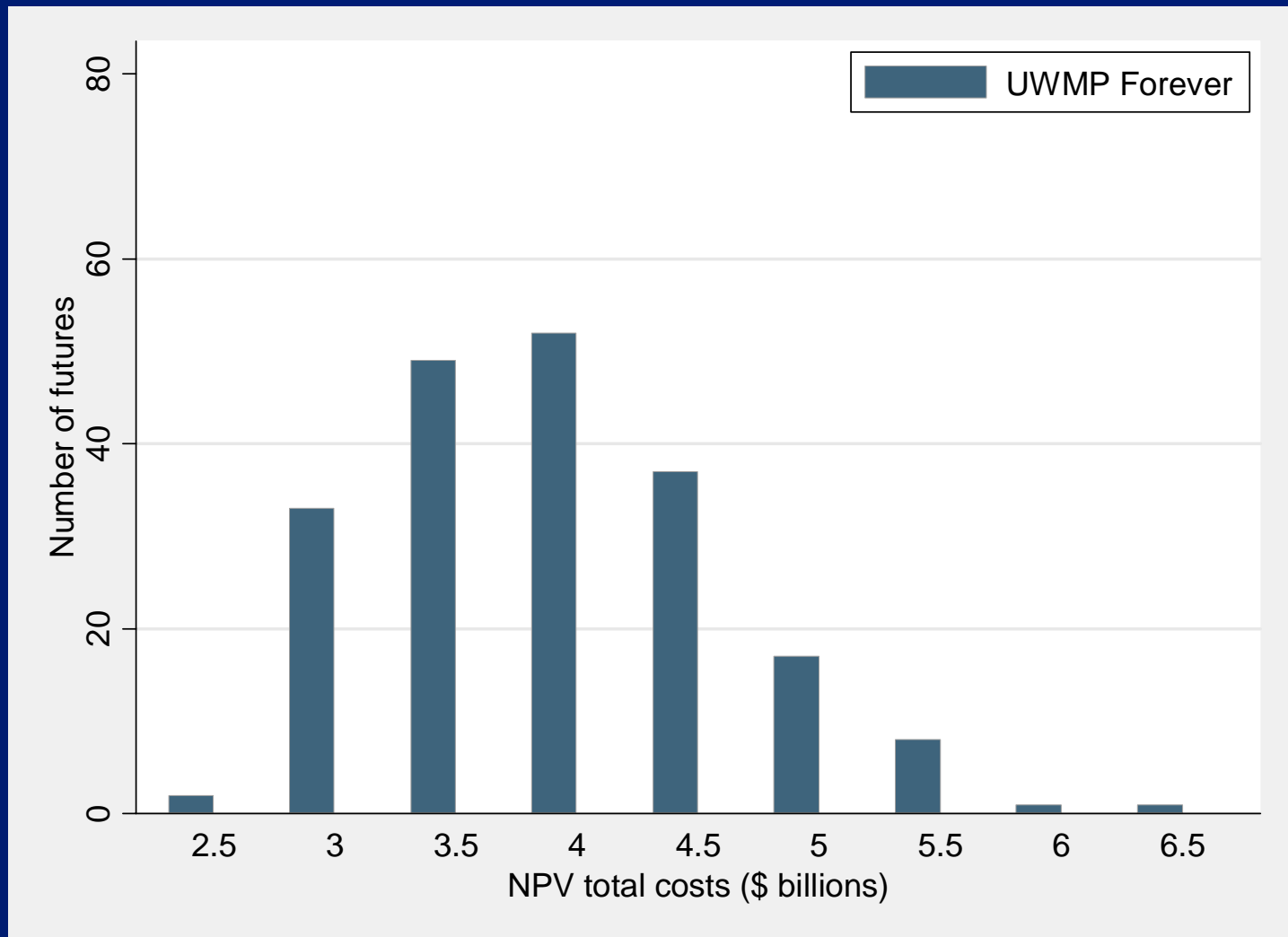
**Impact of climate of MWD  
supplies**

**Basin-wide percolation changes**

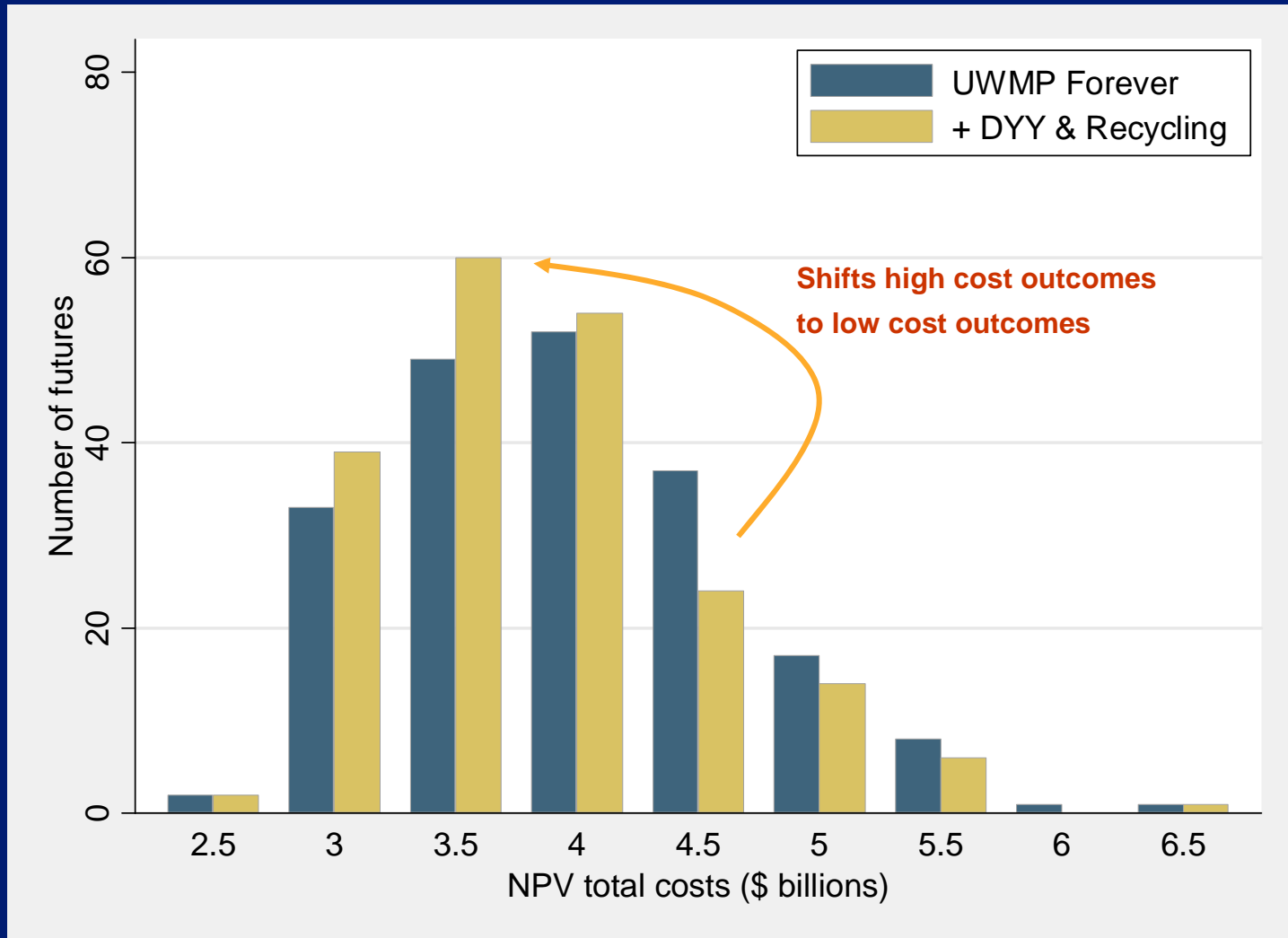
**Imported supply cost increases**

**Efficiency cost increases**

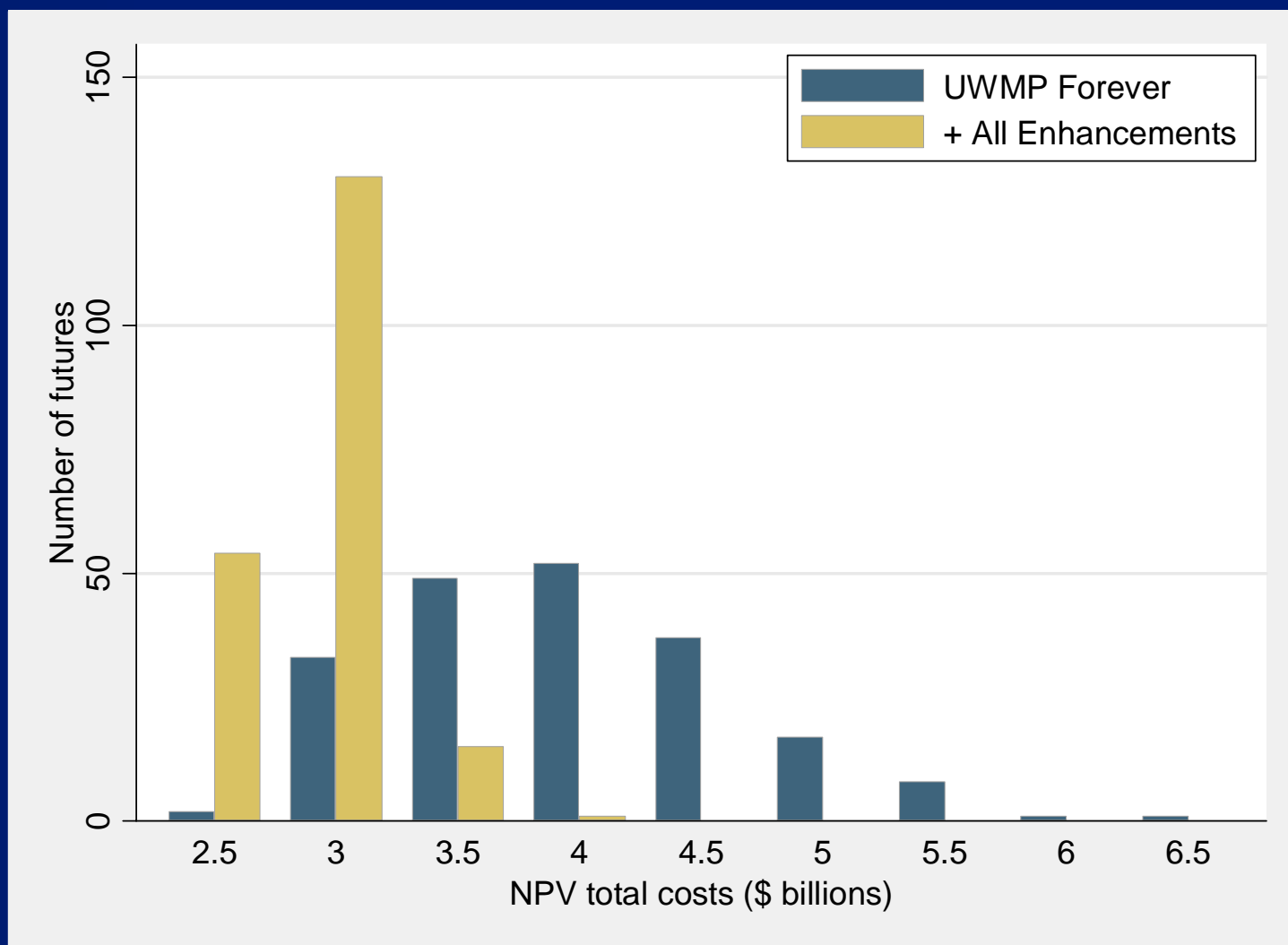
# *We Compared the Performance of Each Plan Across Hundreds Of Scenarios*



# *Implementing Additional Management Options Now Reduces High Cost Outcomes*

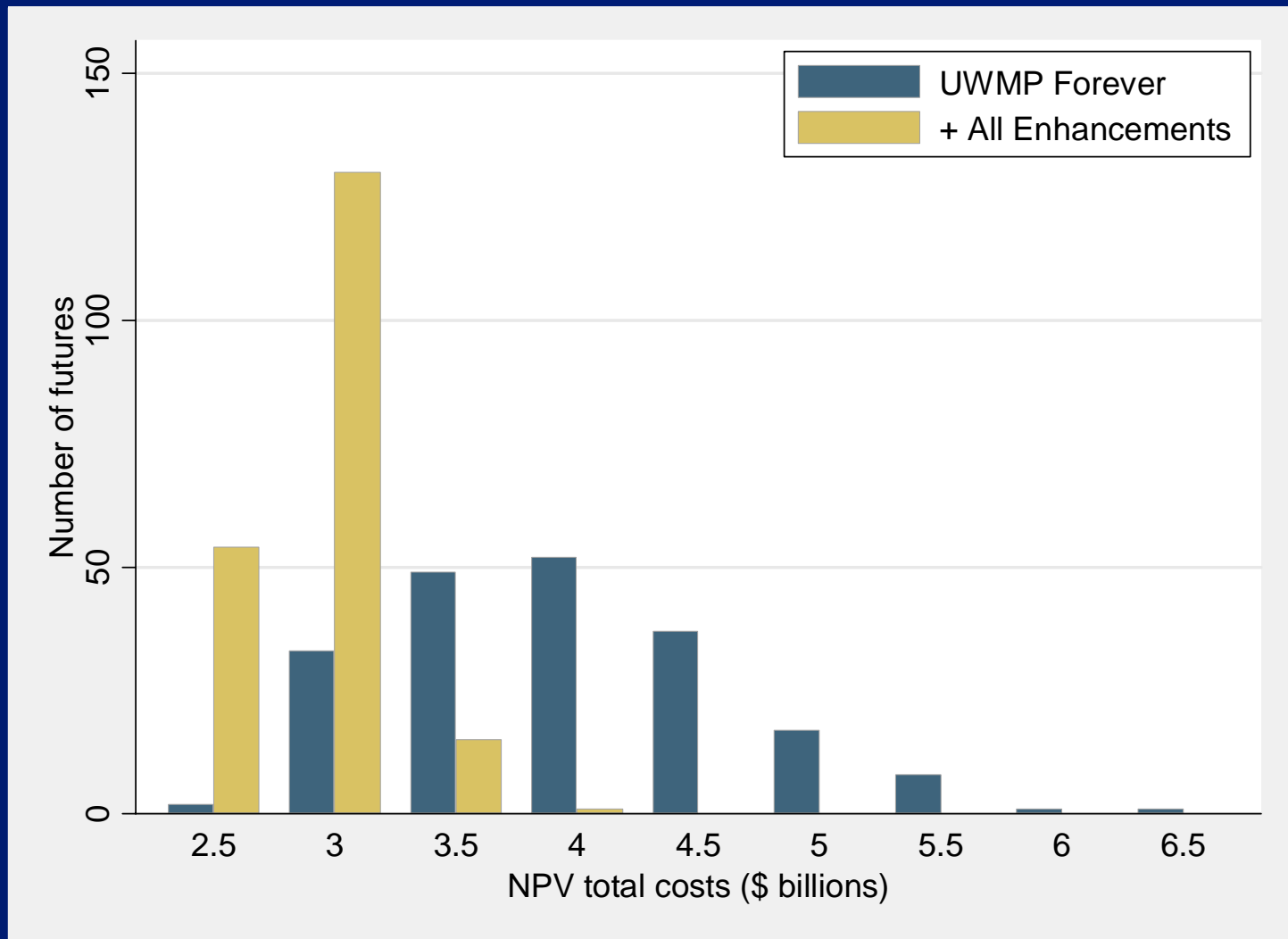


# *Including, Doing All Enhancements Now*

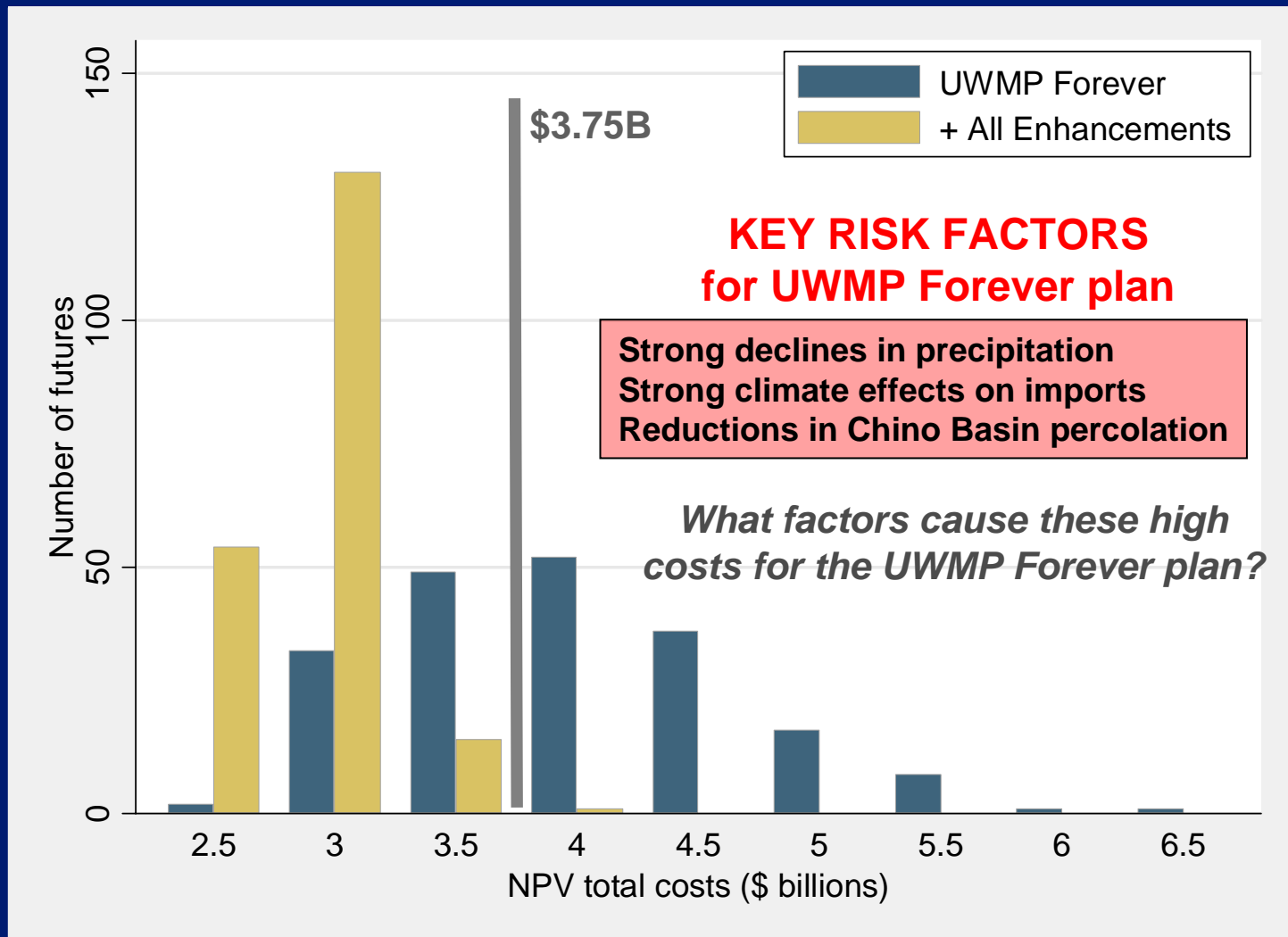




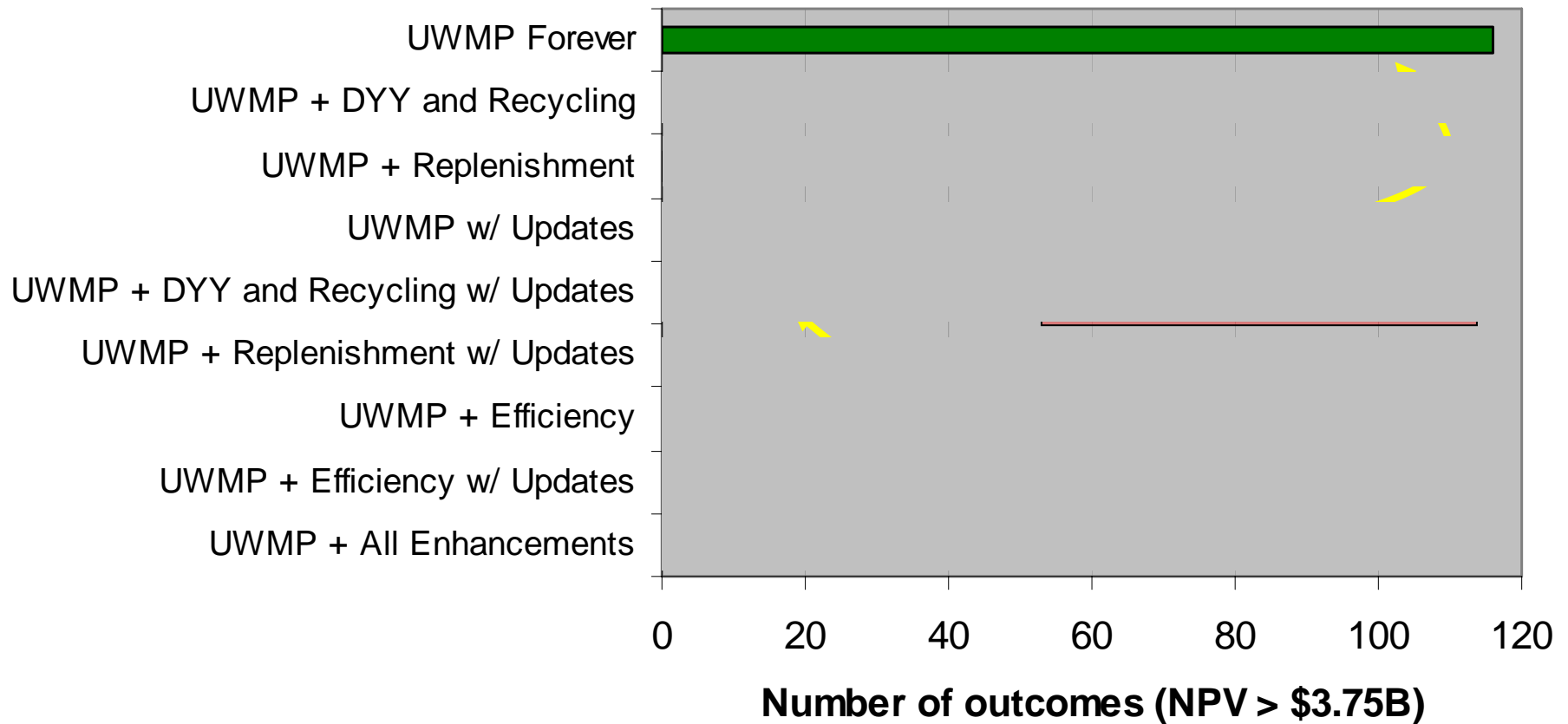
# *All Enhancements Plan Will Protect IEUA Against Many Adverse Conditions*



# All Enhancements Plan Will Protect IEUA Against Many Adverse Conditions




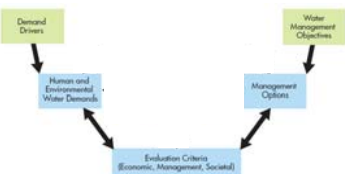
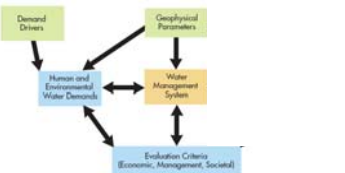

# *Investment in Local Resources Now Buys Down Risk to Key Vulnerabilities*



# *Summary*

- The IEUA UWMP performs well under many potential changes in climate
- Risks remain with UWMP if nothing more is done, now or in future
- Risk can be bought down now or in the future
- But acting now
  - is more effective at reducing future shortages
  - reduces near-term supply costs to the region

# Summary of Scenario Applications

	Scenario Framework	Geological domain	Level of integration	Level of System detail	Climate/hydrology
2005 CWP		Statewide, by Hydrologic Region	No integration between demand scenarios and management options	Coarse demand factor representation. Management options derived from other studies	Annual data for past hydrology (water portfolios), no climate or hydrologic signal in scenarios
Simple Scenarios for Southern California		Southern California. Demand by county, supply by region	Arithmetic combination of supply and demand. Factor changes to baseline estimates	Coarse demand factor representation. Management options derived from other studies and related to supply and demand projections	Annual projections of supply and demand. No interannual variability. No climate signal.
Sacramento WEAP application		Sacramento Basin, including Bay-Delta and Trinity Diversion	Full integration with demand and supply elements interacting dynamically during simulation	Full system detail with all critical system components represented explicitly	Monthly precipitation, temperature, RH and wind. Rainfall/snowmelt simulation->runoff. Water quality simulation.
Robust management strategies for IEUA		Inland Empire Utilities Agency service area.	Integrated supply and demand and long-term water management plans	Aggregated representation of large system components.	Monthly precipitation, temperature, RH and wind. Rainfall/snowmelt simulation->runoff. Parameterizations of effects on imports.
2009 CWP	???	???	???	???	???